March 24, 1870.

Lieut.-General Sir EDWARD SABINE, K.C.B., President, in the Chair.

The following communication was read :—

"On the *Madreporaria* dredged up in the Expedition of H.M.S. 'Porcupine.'" By P. MARTIN DUNCAN, M.B. Lond., F.R.S., Sec. Geol. Soc., Professor of Geology in King's College, London. Received February 26, 1870.

Professor Wyville Thomson, Dr. Carpenter, and Mr. Gwyn Jeffreys have placed the collection of stony corals dredged up by them in the 'Porcupine' Expedition in my hands for determination. They have kindly afforded me all the information I required concerning the localities, depths, and temperatures in which the specimens were found.

My report has been rendered rather more elaborate than I had intended, in consequence of the great consideration of Professor A. Agassiz and Count de Pourtales in forwarding me their reports* and specimens relating to the deep sea-dredging off Florida and the Havana.

They have enabled me to offer a comparison between the British and American species, which I had not hoped to do before the publication of this communication.

CONTENTS.

I. List of the species, localities, depths, temperatures.
II. Critical notice of the species.
III. Special and general conclusions.

I. Twelve species of Madreporaria were dredged up, and the majority came from midway between Cape Wrath and the Faroe Islands. Others were also found off the west coast of Ireland. Many varieties of the species were also obtained, and some forms which hitherto have been considered specifically distinct from others, but which now cease to be so†. [See Table, p. 290.]

List of species known only on the area dredged, or in the neighbouring seas.

1. Amphihelia atlantica, *nobis*.
2. —— ornata, *nobis*.
3. Allopora oculina, *Ehrenberg*.

* Contributions to the Fauna of the Gulf-stream at great depths, by L. F. de Pourtales, 1st & 2nd series, 1868. Bull. Mus. Comp. Zool. Harvard College, Cambridge, Mass., Nos. 6 & 7.

† One specimen came from the 'Lightning Expedition. It must be remembered that all th deep-sea corals known to British naturalists were not dredged up. The *Stylaster rosea*, for instance, was not amongst the collection.

List of Madreporaria.

Name.	No.	Latitude.	Longitude.	Depth.	Temperature.	Remarks.
		° ′	° ′	fathoms.	°	
1. Caryophyllia borealis, *Fleming*	2	51 57 N.	10 23 W.	30–40	52·00	Specimens very numerous.
Syn. C. clavus	...	.....	.....	.....	.....	The species is found in the coralliferous British seas and
C. Smithii	88	59 26 N.	8 23 W.	705	42·65	Mediterranean. Fossils in Miocene and Pliocene of Sicily.
C. cyathus and many varieties						At great depths in Mediterranean (recent).
2. Ceratocyathus ornatus, *Seguenza*.....	88	.....	.....	705	42·65	One specimen. Not known elsewhere; the genus is, with this exception, extinct. The species is fossil in the Sicilian Miocene.
3. Flabellum laciniatum, *Ed. & H.*.....	3	51 51 N.	11 50 W.	370	.....	Specimens numerous.
Syn. Ulocyathus arcticus, *Sars* ...	25	56 41 N.	13 39 W.	164	46·5	This is a well-known Norwegian recent form.
4. Lophohelia prolifera, *Pallas*, sp.	5	52 4 N.	12 8 W.	364	48·8	Specimens numerous.
Syn. All the species hitherto published, viz.:—						The variability of this species at different depths is so great that all the known species must in consequence be considered varieties of one form. Recent in Norwegian seas, Mediterranean, and off the Shetlands. Fossil in Miocene and Pliocene deposits of Sicily. A variety is found off the American coast. A considerable number of specimens was found in the "cold area" at depths from 500–600 fathoms.
L. anthophyllites, *Ed. & H.* ..	13	53 42 N.	13 55 W.	208	49·6	
L. subcostata, *Ed. & H.*	14	53 49 N.	13 15 W.	173	49·6	
L. affinis, *Pourtales*	15	54 5 N.	12 7 W.	422	47·0	
L. Defrancei, *Defrance*	25	56 41 N.	13 39 W.	164	46·5	
L. gracilis, *Seguenza*	54	59 56 N.	6 27 W.	363	31·5	
and several varieties.						
5. Amphihelia profunda, *Pourtales*, sp.	54	59 56 N.	6 27 W.	363	31·5	Many specimens.
6. —— oculata, *Linnæus*, sp.	54	.....	.....	.....	.....	The necessity for absorbing *Diplohelia* is stated in the following pages.
7. —— miocenica, *Seguenza*	54	.....	.....	.....	.....	The species of *Amphihelia* range from the Miocene to the
8. —— atlantica, *nobis*	54					present day; but only *A. oculata* has hitherto been found
9. —— ornata, *nobis*	54					in recent fauna.
10. Allopora oculina, *Ehrenberg*.....	54	.....	.....	.....	.....	A few specimens.
		59 40 N.	7 10 W.	530	47·0	Dredged in 'Lightning' Expedition. A recent form.
11. Balanophyllia (Thecopsammia) socialis, *Pourtales*, sp.	54	59 56 N.	6 27 W.	363	31·5	These are West-Indian forms, and are included in *Thecopsammia*, a subgenus, by Pourtales.
var. costata						
britannica						
Jeffreysia	65	61 10 N.	2 21 W.	345	29·9	
12. Pliobothrus symmetricus, *Pourtales*	...	.....	.....	500–600	Cold area.	It is a West-Indian form.

Total species, 12; species absorbed, 9. Good varieties numerous. Greatest depth from which species were dredged, 705 fathoms.
Lowest temperature of sea at bottom whence corals were dredged, 29°·9.

List of species common to the area and to the Florida and Havana deep-sea faunas only.

1. Balanophyllia socialis, *Pourtales*, sp.
2. Amphihelia profunda, *Pourtales*, sp.
3. Pliobothrus symmetricus, *Pourtales*, sp.

These forms are not known in the West-Indian Cainozoic fauna, and they have not been discovered in any European deposits.

Lophohelia prolifera (var. *affinis*) is common to the British and Florida deep-sea faunas; it is found fossil in the Sicilian Tertiaries, being moreover a member of the recent fauna of the Mediterranean.

List of species common to the area and to the Mediterranean Sea.

1. Caryophyllia borealis, *Fleming*.
2. Amphihelia oculata, *Linnæus*, sp.
3. Lophohelia prolifera, *Pallas*, sp.

List of species found on the area dredged, and as fossils elsewhere.

1. Caryophyllia borealis, *Fleming*. Sicilian: Miocene and Pliocene.
2. Ceratocyathus ornatus, *Seguenza*. Sicilian: Miocene and Pliocene.
3. Flabellum laciniatum, *Ed. & H.* Sicilian, Calabrian: Miocene and Pliocene.
4. Lophohelia prolifera, *Pallas*, sp. Sicilian: Miocene and Pliocene.
5. Amphihelia miocenica, *Seguenza*. Sicilian: Miocene and Pliocene.

The deep-sea coral-fauna of the area dredged in the 'Porcupine' and 'Lightning' Expeditions is therefore composed of:—

5 species which have lasted since the early Cainozoic period.
1 Mediterranean species not known in Cainozoic deposits.
3 species of the deep-sea fauna of Florida and Havana.
3 indigenous species.

12

Two of the fossil species are represented in the recent fauna of the Mediterranean.

If the species which I have absorbed into others (in consequence of the light thrown upon the amount of variation in the deep-sea corals) were counted, the fossil forms would be in all 8.

The greatest depth from which *Madreporaria* were dredged was 705 fathoms, and the lowest temperature of the water in which they lived was 29°·9.

II. *Caryophyllia borealis*, Fleming.—Having collected a veryconsiderable series of the *Caryophylliæ* from the seas around Great Britain, and having been supplied with several specimens of the Mediterranean species, I had some time ago compared the whole with the fossil forms from the Sicilian

tertiary deposits and with each other. The numerous specimens of *Caryophylliæ* dredged up in Dingle Bay were especially interesting after I had arrived at satisfactory conclusions respecting the affinities of the above-mentioned British and Southern-European forms. The Dingle-Bay collection presented all the varieties of shapes (some of which had been deemed of specific value) which I had observed in the separate assemblages of specimens from the Mediterranean, the Sicilian tertiaries, and the British and Scottish seas.

A perfect series of specimens from all these localities can be so arranged as to show a gradual structural transition from form to form; so that the most diversely shaped *Caryophylliæ* can be linked together by intermediate shapes. The *Caryophyllia clavus* and *Caryophyllia cyathus* can be united by intermediate forms, and all of these to *Caryophyllia Smithii* and *Caryophyllia borealis*.

It is impossible to determine which is the oldest form; but they all appear to be reproduced by variation on some part of the area tenanted by the section of the genus. The variability of the *Caryophylliæ* of the Sicilian tertiary deposits is very marked; and it is equally so in the groups which live on disconnected spots in our waters. The Dingle-Bay series presents the greatest amount of variability, and indeed is most instructive; for by applying the range of it to the classification of such genera as *Trochocyathus* and *Montlivaltia* a great absorption of species must ensue.

The Dingle-Bay *Caryophylliæ* are evidently the descendants of those which lived in the Western and Southern-European seas before those great terrestrial elevations took place which were connected with the corresponding subsidence of the circumpolar land and the subsequent emigration of Arctic mollusca. They are not closely allied to the recent West-Indian species; but they occupy a position in the Coral-fauna representative of them. The same remark holds good with reference to the affinities of the recent and the cretaceous *Caryophylliæ*. They are not closely allied, and they belong to different sections of the genus; but they hold the same positions in the economy of the old and new distribution of animal life, and the recent forms are representative of the older. The examination of the Dingle-Bay *Caryophylliæ* tends to prove that a species is really the sum of the variations of a series of forms.

A specimen was dredged up in 705 fathoms, temp. 42°·65 F., and it exactly resembles forms which are frequently found in 90 fathoms, and at a temperature slightly below that of the surface. M. Alphonse Milne-Edwards obtained some *Caryophylliæ* from the cable between Corsica and Algiers in 1110–1550 fathoms. The bathymetrical range of these forms is therefore very great. I have placed the species *borealis* in the first place, and regard the old species *C. clavus*, *C. Smithii*, and *C. cyathus* as varieties of it.

Ceratocyathus ornatus, Seguenza.—A beautiful specimen of this rare form was dredged up from a depth of 705 fathoms with some *Caryophylliæ*

and a small *Isis*. The species is hitherto unknown except in the Sicilian miocene*.

Flabellum laciniatum, Ed. & H.—This is the *Ulocyathus arcticus* of the late Prof. Sars. Many specimens were dredged up; but most of them were broken, in consequence of the extreme fragility and delicacy of the theca. There are no pali; therefore Sars's terminology is not in accordance with the received system. The form was familiar to me from Seguenza's drawing of a dilapidated *Flabellum* (which is always found broken*); and it is now evident that *Ulocyathus* must give place to *Flabellum*. The species links *Flabellum* to *Desmophyllum*: it is not known in the recent Mediterranean fauna.

Lophohelia prolifera, Pallas, sp., is apparently a common coral in the north-western British seas.

				Temperature.
				°
It was dredged up in No. 5 at a depth of	364	fathoms	..	48·8
13	„	208	„	.. 49·6
14	„	173	„	.. 49·6
15	„	422	„	.. 47·0
25	„	164	„	.. 46·5
54	„	363	„	.. 31·5

and also at a depth of from 350 to 600 fathoms in the cold area to the north-west.

All the specimens show great density of the calcareous skeleton; and active nutrition may be inferred on account of the repeated gemmation, the large size of the calices, and the numerical development of the septa. Great variability occurs in the corallites forming a stem; and the shape of the calices is very diverse.

It is very interesting to find some specimens bearing elongate and more or less claviform corallites with the peculiar gemmation of *Lophohelia anthophyllites*, Ellis and Solander, on some portions of their stem, and the usual-shaped corallites of *Lophohelia prolifera* on others.

A separate corallum, which must be referred to *Lophohelia anthophyllites*, Ellis and Solander, was dredged up at No. 54.

The variation of the gemmules of several specimens is sufficiently great to absorb *Lophohelia subcostata*, Ed. & Haime; for fragments of the corallum of *Lophohelia prolifera* exist which possess all its so-called specific peculiarities.

A careful examination of *Lophohelia Defrancei*, Defrance, sp., from the Messinese Pliocene and Miocene deposits, and a comparison of its structure with the numerous specimens dredged up in the 'Porcupine' Expedition, lead me to believe that it is identical with *Lophohelia prolifera*.

* Seguenza, "Disquisiz. Paleont. int. ai Corall. Foss.," Mem. della Reale Accad. dell. Sci. Torino, serie ii. tomo xxi. 1864.

The same identity must be asserted for *Lophohelia affinis*, Pourtales, which was dredged up in 195 fathoms off Coffin's Patches, Florida.

Lophohelia prolifera exists in the Mediterranean Sea and the sea between Scotland and Norway.

Lophohelia anthophyllites is an East-Indian form ; but its absorption into *Lophohelia prolifera* suggests explanations concerning the Cainozoic progenitor, and how it migrated eastwards.

The relation of the recent East-Indian Coral-faunas to those of the European and West-Indian Cainozoic deposits has been noticed and admitted for some years past.

The Cainozoic *Lophohelia* of Sicily is the earliest form of the genus ; and those which are found in such remote parts of the world as the East Indies, the Florida coast, the Norwegian coast, and the Mediterranean, and which have been determined to belong to different species, are, from the study of the curious assemblage of variable forms now under consideration, evidently varieties of the old type, *Lophohelia prolifera*. I have therefore absorbed the old species *L. anthophyllites*, *L. subcostata*, *L. affinis*, *L. Defrancei*, and *L. gracilis*.

Two genera of the *Oculinidæ* in the classification of MM. Milne-Edwards and Jules Haime have always been most difficult to distinguish ; and now the results of the dredging off the north of Scotland and off Florida and the Havana necessitate the absorption of one of them.

Amphihelia and *Diplohelia*.—The first containing recent species only at the time of the enunciation of the classification just referred to, and the last having fossil species only, were very likely to be considered separate genera. *Diplohelia* had species in the Eocene and in the Cainozoic seas. *Amphihelia* was known to have species in the Mediterranean fauna, and in that of Australia also. Seguenza, however, described some *Amphiheliæ* and *Diploheliæ* from the Sicilian tertiary deposits which were identical so far as generic attributes are considered, the only distinction being a doubtful raggedness of the septal edges. The habit and the method of growth and gemmation of the forms were the same. M. de Pourtales dredged up a branching form from off the Havana in 350 fathoms, and from off Bahia Honde, near Florida, in 324 fathoms, and also in lat. 28° 24′ N., long. 79° 13′ W., in 1050 fathoms (came up with the lead). This he named *Diplohelia profunda*. On referring to Seguenza's plates and descriptions* of the fossil corals from the Sicilian Tertiary deposits, there is no difficulty in deciding upon the very close affinity of the species described by Pourtales and *Diplohelia Meneghiniana*, Seg., and *Diplohelia Doderleiniana*, Seg., fossil forms from the mid-tertiary deposits.

But on comparing these forms with one exquisitely figured by Seguenza, and which he calls *Amphihelia miocenica*, Seg., the generic affinities of all become startlingly evident (tab. xii. figs. 1*b*, 1*c*, 3*b* & 3*c*, *op. cit.*).

The very numerous specimens of small branching *Oculinidæ* which

* Seguenza, *l. c.*

were dredged up in the 'Porcupine' Expedition (No. 54, and to the north-west of that spot in the cold area), at a depth of from 363 to 600 fathoms, present singular variations of structure in the buds and calices upon the same stems. A comparison between them and the well-known recent and fossil *Amphiheliæ*, the fossil and recent *Diplohelieæ*, and the smaller specimens of *Lophoheliæ*, leads to the belief that *Amphihelia* is identical generically with *Diplohelia*, and very closely allied to *Lophohelia*. Indeed the distinction between the *Lophoheliæ* and *Amphiheliæ* is of the slightest kind.

The species of the genus *Amphihelia* dredged up in the 'Porcupine' Expedition are five:—

1. Amphihelia (Diplohelia) profunda, *Pourtales*, sp.
2. —— oculata, *Linnæus*, sp.
3. —— miocenica, *Seguenza*.
4. —— atlantica, *nobis*.
5. —— ornata, *nobis*.

The species came from No. 54 dredging, and from the cold area to the north-west in from 500 to 600 fathoms.

The specimens are exceedingly beautiful, strong, and perfect; and there was much difficulty experienced in removing the polypes from the calices.

1. *Amphihelia profunda*, Pourtales, sp., has been noticed. It is a West-Indian form closely allied to a Sicilian miocene species.

2. *Amphihelia oculata*, Linnæus, sp., is well known in the Mediterranean, and has not hitherto been found in the Atlantic.

3. *Amphihelia miocenica*, Seguenza, is a very common species in the deep sea, but is rare in the miocene deposits of Sicily. Its fully developed costal structures distinguish it from the other forms.

4. *Amphihelia atlantica*, nobis, is a new species, large, bushy, and with almost plain cœnenchyma, which is very abundant.

5. *Amphihelia ornata*, nobis, is a new species closely allied to the miocene form, but its ornamentation is most peculiar, and not continuously costulate.

Allopora oculina, Ehrenberg.—Several specimens of this very rare coral were dredged up in No. 54, and one in the 'Lightning' Expedition, not far from the same spot.

The type is in the Berlin Museum; the locality whence it came is unknown.

The distinction between these massive and densely hard corals (whose calices are principally on one side of the cœnenchyma of the stem) and the *Stylasters* is very evident.

M. de Pourtales has described a pretty red-coloured *Allopora miniata* dredged in 100 to 324 fathoms off the Florida reef; but it is very distinct from the species discovered in the late deep-sea dredging expeditions.

Allopora has no fossil representatives.

Balanophyllia (*Thecopsammia*) *socialis*, Pourtales.—Six specimens of a

simple perforate coral were dredged up in lat. 59° 56′ N., long. 6° 27′ W., 363 fathoms, temperature 31°·8 (No. 54), and one in lat. 61° 10′ N., long. 2° 21′ W., 345 fathoms, temp. 29°·9 (No. 65).

The six specimens are of different sizes and ages; and although they present considerable variation in shape and septal development, they evidently belong to one type. The solitary coral from No. 65 is larger than the others, but it belongs to the same species.

Notwithstanding the temperature in which the corals were found, and the depth of the sea, they are strong and well-developed forms, evidencing an active and abundant nutrition.

There is no difficulty in classifying the specimens with the *Thecopsammiæ* of Pourtales.

Thecopsammia socialis, Pourtales, was dredged up in from 100 to 300 fathoms, off Sombrero, near Florida, in the course of the Gulf-stream.

I have been able to compare the specimens dredged up in the 'Porcupine' Expedition with M. Pourtales's types, and, after making due allowance for variation, I have no doubt about including the British forms under his specific term. These varieties of the Floridan type, found at greater depths, and doubtless in much colder water, present evidences of greater vigour than the American forms. They are larger and denser, and their septa are better developed. Moreover some of them, although they possess all the other characteristics of the genus as diagnosed by Pourtales, present indubitable costæ, especially inferiorly. This clinging to the Balanophyllian type is not witnessed in the Floridan forms; but it is too important to be passed over, especially as it renders the generic distinction between many well-known *Balanophylliæ* and the new *Thecopsammiæ* very unstable. The *Thecopsammiæ*, from the peculiarities of their wall, epitheca, and septa, well merit the distinction of a subgenus; and therefore I propose to restore the species associated under the term to the genus *Balanophyllia*, in the subgenus *Thecopsammia*.

Balanophyllia (*Thecopsammia*) *socialis*, Pourtales, var. *costata*. No. 54, 'Porcupine' Expedition.

—— (——) ——, var. *britannica*. No. 54, 'Porcupine' Expedition.

—— (——) ——, var. *Jeffreysia*. No. 65.

All these varieties refer to specimens which were fixed by their bases to stones.

The varieties and the original types are very isolated forms in the great genus *Balanophyllia*. They have only a very remote affinity with the West-Indian recent *Balanophylliæ*, with those of the Crag, the Faluns, and the Eastern Tertiaries.

The British forms appear to have emigrated from the south-west; and probably the original type wandered through the agency of the Gulf-stream, which carried the ova and deposited them in our northern sea, where they have propagated, varied, and thriven.

Pliobothrus symmetricus, Pourtales.—A specimen of this doubtful coral (which had been described by M. de Pourtales from the results of dredging in from 100 to 200 fathoms) was sent to me by Dr. Carpenter. It came from the cold area, in from 500 to 600 fathoms.

There is no doubt that this very polyzoic-looking mass belongs to the American type. The tabulæ are hardly worthy to be called such; and I place the form amongst the Zoantharia provisionally.

III. The species of *Madreporaria* belong to genera which do not contribute and have not contributed to form coral-reef faunas. None of them are reef-builders; but all are essentially formed to live where rapid growth and delicately cellular structures are not required. The forms are strong, solid, and large; and their rapid and repeated gemmation proves that their nutritive processes went on actively and continuously.

All the species are very much disposed to produce variations; and this is especially true as regards those which have outlived the long age of the Crag, the glacial period, and the subsequent time of elevations and subsidences. The least-variable species are those which are not known on other areas.

Two of the three species which are common to the West-Indian deep-sea fauna and that of our north-western coasts are also very variable.

The persistence of *Madreporaria* from the earlier Cainozoic period to the present time has been an established fact for several years. Some of the forms which are common to the deep sea of the British area and to the so-called miocene of Sicily are still existing in the Mediterranean. None, however, of the species of Corals found in the British Crag are represented in the deep-sea fauna.

The existence of Mediterranean forms in the North-west British area is in keeping with the discoveries of Forbes. It has, however, a double significance, and bears upon the presence of West-Indian forms on the North-west British marine area. There was a community of species between the Mediterranean and the West Indies in the Cainozoic period, especially of Echinodermata, Mollusca, Madreporaria, and Foraminifera. After the great alterations of the mutual relations of land and sea which took place before the cold affected the fauna of the Franco-Italian seas, this community of species diminished; but it lasted through all the period of Northern glacialization, and is proved still to exist slightly by comparing the Algæ, the Corals, the Echinodermata, and the Mollusca.

The presence of two very characteristic Floridan species, and one less so, off the north of Scotland, is particularly interesting, because they all live in the cold area and flourish there, whilst they appear to be less vigorous in the warmer Gulf-stream near Florida.

It is impossible to fail to recognize the operation of this stream in producing the emigration of these three species, which are essentially American.

The solidity and the power of gemmation of the corals within the cold area

appear to be greater than elsewhere. Depth has not much effect upon the nutrition of the *Madreporaria*; for those dredged up at 600 fathoms are quite as hard and solid as those found at 300 fathoms.

All the calices were stuffed with small Foraminifera, and there was evidently a great abundance of food.

There were numerous Polyzoa, Sponges, Foraminifera, Diatomaceæ, and delicate bivalves associated with or fixed upon the corals at all depths. Moreover, at from 300 to 400 fathoms, some *Amphiheliæ* had incrusted an Annelid.

Serpulæ, moreover, abound upon the corals; and a pretty *Isis* was associated with them at a depth of 705 fathoms. This is a fauna which, if covered up and presented to the palæontologist, would be, and would have been for some years past, considered a deep-sea one.

It is a fauna which indicates the existence of the same processes of nutrition and of destructive assimilation and reproduction which are recognized in association with corresponding forms at less depths and in higher temperatures.

The great lesson which it reads is, that vital processes can go on in certain animals at prodigious depths, and in much cold, quite as well as in less depths and in considerable heat. It suggests that a great number of the Invertebrata are not much affected by temperature, and that the supply of food is the most important matter in their economy.

The researches of Hooker, who obtained Polyzoa and Foraminifera in soundings at a depth of nearly 400 fathoms off the icy barrier of the South Pacific, of Wallich in the Atlantic, and of Alphonse Milne-Edwards in the Mediterranean have had much influence upon geological thought in this age, which, so far as geologists are concerned, is remarkably averse to theory. For many years before any very deep soundings had been taken with the view of searching the sea-bottom for life, geologists had more or less definite opinions concerning the deposition of organisms in sediments at great depths. Certainly more than thirty years ago deep-sea deposits were separated by geologists from those which they considered to have been formed in shallower seas. The finely divided sediment of strata containing Crinoids, Brachiopods, Foraminifera, and simple Madreporaria was supposed to have been deposited in deeper water than formations containing large pebbles, stones, and the mollusca whose representatives now live in shallows. The relations of such strata to each other during subsidence, the first being found occasionally to overlap the last, proved that there was a deeper sea-fauna in the offing of the old shores which were tenanted by littoral and shallow-water species. The deposition of strata containing Foraminifera, Madreporaria, and Echinodermata, whose limestone is remarkably free from any foreign substances, has been considered to have taken place in very deep water; this theory has been founded upon the observations of the naturalist and mineralogist. Indeed no geologist has hesitated in assigning a great depth to the origin of some

deposits in the Laurentian, Silurian, or in any other formation. The "flysch," a great sediment of the Eocene formation, has been considered to have been formed at a great depth and under great pressure. Its singularly unfossiliferous character was supposed to be due to the absence of life at the depths of the ocean where the sediment collected. But this was a theory of the early days of geology, when the destructive influence of chemical processes in strata upon the remains of organisms in them was hardly admitted.

The great value of such researches as those so ably carried out by Thomson, Carpenter, and Jeffreys is the definite knowledge they impart to the geologist, who is theorizing in the right direction, but whose notions of the depth at which the sediments containing Invertebrata can be deposited are indefinite. These researches contribute to more exact knowledge, and they will materially assist the development of those hypotheses which are current amongst advanced geologists into fixed theories. I do not think that any geological theory worthy of the term, and which has originated from geological induction, will be upset by these careful investigations into the bathymetrical distribution of life and temperature. The theories involving pressure and the intensity of the hardness of deep-sea deposits will suffer from the researches; but many difficulties in the way of the palæontologist will be removed. The researches tend to explain the occurrence of a magnificent deep-sea coral-fauna in the Palæozoic times in high latitudes, and of Jurassic and Cainozoic faunas on the same area, and they favour the doctrines of uniformity. They explain the cosmopolitan nature of many organisms, past and present, which were credited with a deep-sea habitat, and they afford the foundations for a theory upon the world-wide distribution of many forms during every geological formation.

It is not advisable, however, to make too much of the interesting identities and resemblances of some of the deep-sea and abyssal forms with those of such periods as the Cretaceous, for instance. In the early days of geological science there was a favourite theory that at the expiration of a period the whole of the life of the globe was destroyed, and that at the commencement of the succeeding age a new creation took place. There were as many destructions and creations as periods; or, to use the words of an American geologist, there was a succession of platforms. This theory held back the science, just as the theory that the sun revolved round the earth retarded the progress of astronomy. Moreover it had that armour of sanctity to protect it which is so hard to pierce by the most reasonable opposition. Nevertheless every now and then a geologist recognized the same fossils in rocks which belonged to different periods. A magnificent essay by Edward Forbes on the Cretaceous Fossils of Southern India, a wonderful production and far before its age *, gave hope and confidence to the few palæontologists who began to assert that

* Quart. Journ. Geol. Soc. vol. i. p. 79.

periods were perfectly artificial notions—that it did not follow, because one set of deposits was forming in one part of the world, others exactly corresponding to it elsewhere, so far as the organic remains are concerned, were contemporaneous—and that life had progressed on the globe continuously and without a break from the dawn of it to the present time.

The persistence of some species through great vertical ranges of strata, and the relation between the world-wide distribution of forms and this persistence were noticed by D'Archiac, De Verneuil, Forbes, and others. The identity of some species in the remote natural-history provinces of the existing state of things was established in spite of the dogmatic opposition of authorities; and then geologists accepted the theories that there were several natural-history provinces during every artificial period, that some species lived longer and wandered more than others, and that some have lasted even from the Palæozoic age to the present.

Persistence of type was the title of a lecture delivered by Professor Huxley* many years ago; and this persistence has been admitted by every palæontologist who has had the opportunity of examining large series of fossils from every formation from all parts of the world.

Geological ages are characterized by a number of organisms which are not found in others, and by the grouping of numerous species which are allied to those of preceding and succeeding times, but which are not identical. Certain portions of the world's surface were tenanted by particular groups of forms during every geological age; and there was a similarity of arrangement in this grouping under the same external physical conditions. To use Huxley's term, the "homotaxis" of certain natural-history provinces during the successive geological ages has been very exact. The species differed; but there was a philosophy in the consecutive arrangements of high-land and low-land faunas and floras, and of those of shallow seas, deep seas, oceans, and reef-areas. The oceanic† conditions, for instance, can be traced by organic remains from the Laurentian to the present time, and the deep-sea corals now under consideration are representative of those of older deep seas.

It is not a matter for surprise, then, that, there being such a thing as persistence of type and of species, some very old forms should have lived on through the ages whilst their surroundings were changed over and over again. But this persistence does not indicate that there have not been sufficient physical and biological changes during its lasting to alter the face of all things enough to give geologists the right of asserting the succession of several periods. The occurrence of early Cainozoic Madreporaria in the deep sea to the north-west of Great Britain only proves that certain forms of life have persisted during the vast changes in the physical geography of the world which were initiated by the upheaval of the Alps, the Himalayas, and large masses of the Andes. To say that we are therefore

* Royal Institution. See also Pres. Address, Geol. Soc., 1870.

† P. M. Duncan, Quart. Journ. Geol. Soc. No. 101.

still in the Cainozoic or Cretaceous age would hardly be consistent with the necessary terminology of geological science.

During the end of the Miocene age and the whole of the Pliocene the Sicilian area was occupied by a deep sea. The distinction between the faunas of those times and the present becomes less, year after year, as science progresses; and it is evident that a great number of existing species of nearly every class flourished before the occurrence of the great changes in physical geology which have become the artificial breaks of tertiary geologists. That the Cainozoic deep-sea corals should resemble, and in some instances should be identical in species with, the forms now inhabiting vast depths, is therefore quite in accordance with the philosophy of modern geology. Before the deposition of the Cainozoic strata, and whilst the deep-sea deposits of the Eocene age were collecting in the Franco-British area, there was a Madreporarian fauna there which was singularly like unto that which followed it, both as regards the shape of the forms and their genera. Still earlier, during the slow subsidence of the great Upper Cretaceous deep-sea area, there was a coral-fauna in the north and west of Europe, of which the existing is very representative. The simple forms predominate in both faunas. *Caryophyllia* is a dominant genus in either; and a branching *Synhelia* of the old fauna is replaced in the present state of things by a branching *Lophohelia*. The similarity of deep-sea coral-faunas might be carried still further back in the world's history; but it must be enough for my purpose to assert the representative character and the homotaxis of the Upper Cretaceous, the Tertiary, and the existing deep-sea coral-faunas. This character is enhanced by the persistence of types; but still the representative faunas are separable by vast intervals of time.

March 31, 1870.

Lieut.-General Sir EDWARD SABINE, K.C.B., President, in the Chair.

The following communications were read:—

I. "On the Relation between the Sun's Altitude and the Chemical Intensity of Total Daylight in a Cloudless Sky." By HENRY E. ROSCOE, F.R.S., and T. E. THORPE, Ph.D. Received March 3, 1870.

(Abstract.)

In this communication the authors give the results of a series of determinations of the chemical intensity of total daylight made in the autumn of 1867 on the flat tableland on the southern side of the Tagus, about $8\frac{1}{2}$ miles to the south-east of Lisbon, under a cloudless sky, with the object of ascertaining the relation existing between the solar altitude and the